Objections/rejections for Formal Matters

1,2. The specification has been amended to specify that this application is a continuation-in-part of U.S. patent application Serial No. 09/047,704.

3. In view of the Examiner's indication that the application is not entitled to the benefit of the filing date of U.S. patent application Serial No. 08/040,978 under 35 USC 120, the reference to this application has been deleted from the specification. Issuance of a new filing receipt is therefore respectfully requested.

4. A new Declaration and Power of Attorney for this application will be submitted identifying the priority applications and the prior related applications.

5. The specification has been amended at page 13, lines 1 and 7 to correct the informalities noted by the Examiner.

6. Claims 16 and 18 have been amended as suggested by the Examiner in order to overcome the Examiner's objection to claims 16 and 18-20.

7. Claims 6, 8, 16 and 18 have been amended as suggested by the Examiner in order to overcome the Examiner's rejection of claims 7-9, 16 and 18-20 under 35 U.S.C. Section 112, second paragraph. The applicants appreciate the Examiner's thorough review of the claims and proposed suggestions to remove the informalities.

8-9. Claims 1-21 were provisionally rejected under the judicially created doctrine of double patenting over claims 69-93 of U.S. patent application Serial No. 08/640,068.

Although applicants do not agree with the grounds for the double patenting rejections, submitted herewith is a Terminal Disclaimer disclaiming the terminal part of any patent granted on this application which would extend beyond the term of any patent granted on the '068

application, the appropriate fee for submission of a Terminal Disclaimer to be charged to the applicants' Deposit Account.

In view of the submission of the Terminal Disclaimer, the double patenting rejection has been overcome and should be removed.

Rejections on the merits

11. Claims 1-8 and 10-21 were rejected under 35 U.S.C. 102(e) as being anticipated by Corrado et al.

In response to these rejections, submitted herewith is a Declaration of the Inventors under 37 C.F.R. Section 1.131 proving invention of the claimed subject matter by the applicants prior to the effective date of Corrado et al. (its filing date of April 12, 1994) **and** due diligence from prior to April 12, 1994 to the filing of the preceding, priority application Serial No. 08/239,978 filed on May 9, 1994. Although the Declaration is unsigned, a signed original executed by all of the inventors as required by MPEP 715.04 will be submitted shortly.

As set forth in the Declaration, a paper was prepared by two of the inventors, David S. Breed and Wilbur E. DuVall (with the assistance of Vittorio Castelli), on behalf of the assignee, Automotive Technologies International, Inc., for publication at the Society for Automotive Engineers (SAE) annual conference in 1994, which took place February 28 to March 3, 1994 and was published as SAE Paper No. 940527. A copy of the SAE Paper is attached to the Declaration.

Among other things, the SAE Paper discloses a vehicle interior monitoring system including position and velocity determination abilities and pattern recognition abilities (Page 2, Col. 2, last paragraph). The pattern recognition abilities relate to the ability of the described OPS (occupant position sensor) to detect the presence of, e.g., a child seat, on a vehicle seat by means

of a signal based on the contents of the seat (independent claims 1 and 12). Specifically, page 2, second column, last full paragraph recites that:

> "In some cases the presence of an occupant, or of a rear facing child seat, can be used to control the deployment of the airbag...In these cases rather than the determination of the position of the occupant, the pattern of a rear facing child seat or of an occupant must be determined and differentiated from that of a forward facing child seat, a box or a bag of groceries."

In the paragraph bridging pages 3 and 4, the SAE Paper discussed forming a library of tests for the child seat and occupant presence detectors (CSOPDs). Such a library is formed by conducting tests using any one of the technologies mentioned in the section entitled "Technology Comparisons" bridging pages 4 and 5, e.g., passive infrared, ultrasonics and laser optical. Each of these technologies encompasses appropriate "receiving means" for obtaining information about contents of the seat and generate a signal based thereon, a different signal for different contents, for input into the CSOPDs (as set forth in claim 1).

With respect to due diligence from prior to April 12, 1994 to the filing date of the parent application on May 9, 1994, it is respectfully pointed out that during this time, a draft of the application prepared by the assignee's principal patent specialist (the inventor David S. Breed) was being reviewed and revised by the assignee's attorney at his business in Arlington, Virginia to put it into an appropriate form for filing with the USPTO. A copy of the assignee's attorney's bill showing the hours spent on reviewing and revising the draft application is attached to the Declaration. The parent application was designated docket no. ATI-77 and is also referred to by the initials VIMS-Vehicle Interior Monitoring System.

As evidenced by the attached copy of the bill, on April 10-12, 1994, the attorney spent 1 hour on matters on behalf of the assignee (Automotive Technologies International (ATI)) including a review of the draft application for ATI-77 that was forwarded to him shortly before this date by Mr. Breed. Thereafter, the attorney spent 2.5 hours on ATI matters on April 17, 1994 including a review of ATI-77. Further, on April 24, 1994, the attorney spent 1 hour solely revising the draft application for ATI-77 including a telephonic discussion with Mr. Breed regarding the same. On April 26, 1994, the attorney spent an additional 2.75 hours revising the application and on April 27, 1994, the attorney spent an additional 1.75 hours.

At the same time that the attorney was working on revising the draft application to put it into an appropriate form for filing at the USPTO, Mr. Breed was finishing the drawings for the application at his office in Boonton, Township, Morris County, New Jersey . As evidence of this work, submitted herewith is a printout of a list of the drawings prepared for this application indicating the date each drawing was <u>last modified</u>. It should be noted that FIG. 18 was last modified on April 22, 1994, FIGS. 1-6, 9 and 15 were last modified on April 29, 1994, FIGS. 8, 11-14 and 16 were last modified on May 2, 1994 and FIGS. 10 and 19 were last modified on May 3, 1994. Thus, while the attorney was reviewing and revising the application, Mr. Breed was in the process of preparing drawings to file with the application. All of this activity was occurring after conception of the invention and between the effective filing date of the reference, i.e., April 12, 1994, and the constructive reduction to practice, i.e., the filing of patent application designated ATI-77 on May 9, 1994.

Furthermore, after the attorney had completed reviewing the text of the application, a Declaration/Power of Attorney was sent to the remaining inventors for signature. Attached hereto are copies of the Declaration/Power of Attorney forms submitted with the parent

application (ATI-77) showing a signature by the inventor Wendell C. Johnson on May 3, 1994 resident in Topanga, California and by the inventor Wilbur E. DuVall also on May 3, 1994 resident in Kimberling City, Missouri (but on a different document). Thus, these documents were sent to the respective inventor shortly before May 3, 1994 so that they were able to execute the Declarations on May 3, 1994 and thereafter return them to the attorney. The application was subsequently filed on May 9, 1994.

In view of the foregoing evidence, it is respectfully submitted that the applicants were diligent in the filing of this application in the critical time period between April 12, 1994, the filing date of the Corrado reference, and May 9, 1994, the filing date of the parent application.

In any event, it is respectfully submitted that Corrado et al. does not disclose all of the features of all of the claims rejected by the Examiner.

In view of the submission of the Declaration and attachments thereto, it is respectfully submitted that the Examiner's rejection of claims 1-8 and 10-21 in view of Corrado et al. should be removed.

14. Claim 9 was rejected under 35 U.S.C. 103(a) as being unpatentable over Corrado et al. in view of the admitted prior art

The Examiner's rejection is respectfully traversed.

Initially, it is emphatically asserted that although the existence of neural networks preceded the invention herein, the use of neural networks in automotive applications such as set forth in the claims was not considered at the time this invention was made. In other words, the prior art of automotive applications had not considered the use of neural networks as an effective pattern recognition technique for the <u>identification</u> of occupying items in a vehicular passenger compartment.

Furthermore, it is respectfully submitted that one could not combine the use of a neural network with Corrado et al. because the technique of Corrado et al. is not based on the **training** of pattern recognition means, i.e., a trained neural network. In the embodiment of the invention set forth in claim 9, a large number of tests are conducted for different contents of the seat to ascertain the patterns of reflected waves therefrom. The neural network is trained based on the patterns of reflected waves and an indication of the identification of the item. Thereafter, in use, when an electronic signal based on the pattern of reflected waves from the contents of the seat is received by the neural network, it provides the identification of the contents. This system is based on the fact that different items have different patterns of reflected waves. Thus, based on the pattern of reflected waves alone, it is possible to accurately identify the item.

In Corrado et al., there is a matrix of known condition confidence weighted values to which signals from an infrared sensor and ultrasonic sensor are provided and an overall confidence level is obtained which results in the triggering of the enable/disable signal of the airbag controller.

In contrast to the claimed inventions, Corrado et al. is absolutely devoid of any analysis of patterns of reflected waves from either one of the sensors. Thus, there cannot be any pattern recognition means which process a signal based on reflected waves into "a categorization of said signals characteristic of the contents of the seat as set forth in claim 7.

In view of the absence of any such pattern recognition means that are possibly exemplified by a neural network, Corrado et al. cannot be modified to arrive at the claimed invention.

If the Examiner should determine that additional changes to the claims, or changes to the specification, are necessary to place the application in condition for allowance, the Examiner is respectfully requested to contact the undersigned to discuss the same.

An early and favorable action on the merits is earnestly solicited.

FOR THE APPLICANTS
Respectfully submitted,

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Enclosures
Terminal Disclaimer (in duplicate)
Declaration Under 37 C.F.R. Section 1.131 (unsigned)

SAE TECHNICAL
PAPER SERIES

940527

Vehicle Occupant Position Sensing

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Automotive Technologies International, Inc.

The Engineering Society
For Advancing Mobility
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Vehicle Occupant Position Sensing

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ABSTRACT

Regardless of whether crash sensors are mounted in the crush zone or non-crush zone, there will always be crashes where the sensors trigger late and the occupant has moved to a position near to the airbag deployment cover where he or she may be injured by the deployment of the airbag. The required sensor triggering time is now determined by assuming that the occupant is a 50% male sitting in the mid seating position. 70% of vehicle occupants are smaller and, on average, sit closer to the airbag and thus are even more likely to be out-of-position. Finally, current sensor systems make no allowance for occupants that are wearing seatbelts, for rear facing child seats located on the front passenger seat or for unoccupied seats. There are thus strong safety reasons for occupant position sensors.

This paper discusses the above problems, the difficulties in sensing occupants and objects located in the vehicle and attempts to define the requirements for such devices. It also presents some of the added benefits which will result from effective sensors which can characterize the contents of the vehicle such as heating, air conditioning and entertainment systems which adjust to vehicle occupants.

THE MOTIVATIONS FOR PLACING an occupant presence and position sensor into an automobile are:

- A significant number of people are now injured by the deployment of the airbag itself and a smaller number are killed.

- A child in a rear facing child seat on the front seat is in danger if the passenger airbag deploys.

- If the passenger seat is unoccupied deployment of the passenger side airbag needlessly increases the cost to repair the vehicle.

Background

Crash sensors for determining that a vehicle is in a crash of sufficient magnitude as to require the deployment of an inflatable restraint system, or airbag, are either mounted in a portion of the front of the vehicle which has crushed by the time that sensor triggering is required, the crush zone, or elsewhere such as the passenger compartment, the non-crush zone. Regardless of where sensors are mounted there will always be crashes where the sensor triggers late and the occupant has moved to a position near to the airbag deployment cover. In such cases, the occupant may be seriously injured or even killed by the deployment of the airbag. The Occupant Position Sensor is largely concerned with preventing such injuries and deaths by preventing late airbag deployments.

In an SAE paper by Mertz, Driscoll, Lenox, Nyquist and Weber titled "Response of Animals Exposed to Deployment of Various Passenger Inflatable Restraint System Concepts for a Variety of Collision Severities and Animal Positions" (1), the authors show that an occupant can be killed or seriously injured by the airbag deployment if he or she is located out-of-position near or against the airbag when deployment is initiated. There are now many documented occurrences of such injuries and deaths in real world accidents.

All crush zone mounted sensors, in order to function properly, must be located in the crush zone at the required trigger time during a crash or they can trigger late (2). For the purposes here, the crush zone is defined as that portion of the vehicle which has crushed at the time that sensor triggering is required. In impacts with soft objects, the crush of a vehicle can be significantly less than for impacts with barriers for the same velocity change. In such cases, even at moderate velocity changes where an airbag might be of help in mitigating injuries, the crush zone mounted sensor might not actually be in the crush zone at the time that sensor triggering is required and trigger late. In these cases the occupant could become out-of-position when the sensor triggers and be injured or even killed by the deploying airbag.

There is a trend underway toward the implementation of Single Point Electronic sensors which are typically located in the passenger compartment. In theory, these sensors use sophisticated computer algorithms to determine that a particular crash is sufficiently severe as to require the deployment of an airbag. In a recent SAE paper (3), the authors argue that there is insufficient information in the non-crush zone of the vehicle to permit a decision to be made to deploy an airbag in time for many crashes. Thus, sensors mounted in the passenger compartment or other non-crush zone locations, will also trigger the deployment of the airbag late in many crashes and lead to deployment induced injuries.

The discussions of timely airbag deployment above are all based on the position of the average male (designated the 50% male) relative to the airbag or steering wheel. For the 50% male, the sensor triggering requirement is typically calculated based on an allowable motion of the occupant of 13 cm by the time that the airbag is fully inflated. Airbags typically require about 30 milliseconds of time to achieve full inflation and, therefore, the sensor must trigger inflation of the airbag 30 milliseconds before the occupant has moved forward 13 cm. The 50% male, however, is actually the 70% person, considering both males and females, and therefore about 70% of the population are smaller and sit, on average, closer to the airbag than the 50% male, and thus are exposed to a greater risk of interacting with the deploying airbag. A recent informal survey, for example, found that although the average male occupant sits about 30 cm from the steering wheel, about 2% of the population of drivers sit closer than 15 cm from the steering wheel and 10% sit closer than 25 cm. Also, about 1% of drivers sit at about 60 cm and about 16% sit at least 45 cm from the steering wheel. None of the sensor systems now on the market take into account of this variation in occupant seating position and yet this can have a critical effect on the sensor required triggering time.

For example, if a fully inflated driver side airbag is about 28 cm (11 inches) thick, measured from front to back, then any driver who is sitting closer than 28 cm will necessarily interact with the deploying airbag, and at some closer position such as 12 cm (5 inches), the airbag probably should not be deployed at all. These numbers depend, of course, on the particular vehicle and airbag design. For a recently analyzed 48 kph (30 mph) barrier crash of a mid-sized car, the sensor required triggering time in order to allow the airbag to inflate fully before the driver becomes closer than 12 cm from the steering wheel results in a maximum sensing time of 8 milliseconds for a driver initially positioned 18 cm (7 inches) from the airbag, 25 milliseconds at 25 cm, 45 milliseconds at 41 cm and 57 milliseconds for the occupant who is initially positioned at 56 cm from the airbag. Thus for the same crash, the sensor required triggering time varies from a no trigger situation to 57 milliseconds, depending on the initial position of the occupant. A single sensor triggering time criterion that fails to take this into account, therefore, will cause injuries to small people or deny the protection of the airbag to larger people. A very significant improvement to the performance of an airbag system will necessarily result from taking the occupant position into account as described herein.

A further complication results from the fact that a greater number of occupants are now wearing seatbelts which tends to prevent most of these occupants from getting too close to the airbag. Thus, just knowing the initial position of the occupant is insufficient and either the position and velocity must be continuously monitored or the use of the seatbelt must be known. Also, the driver may have fallen asleep or be unconscious prior to the crash, and be positioned against the steering wheel. Some sensor systems have been proposed that double integrate the acceleration pulse in the passenger compartment and determine the displacement of the occupant based on the calculated displacement of an unrestrained occupant seated at the mid-seating position. This sensor system then prevents the deployment of the airbag if, by this calculation, the occupant is too close to the airbag. This calculation can be greatly in error for the different seating positions discussed above and also for the seatbelted occupant, and thus an occupant who wears a seatbelt could be denied the added protection of the airbag in a severe crash.

As the number of vehicles which are equipped with airbags is now rapidly increasing, the incidence of late deployments is also increasing.

The OPS will be installed in the passenger compartment of an automotive vehicle equipped with an inflatable airbag. When the vehicle is subjected to a crash of sufficient magnitude as to require deployment of the airbag, and the sensor system has determined that the device is to be deployed, the OPS and associated electronic circuitry determines the position and velocity of the vehicle occupant relative to the airbag and disables deployment of the airbag if the occupant is positioned so that he is likely to be injured by the deploying airbag. Naturally, the addition of an occupant position sensor onto a vehicle leads to other possibilities as will be discussed below.

Thus far the use of the OPS to disable the airbag deployment has been discussed. Inflators now exist where the gas production rate can be controlled. If an occupant is already close enough to interact with the airbag but not so close that the deployment should be suppressed, a lesser inflation could help the occupant without injuring him. Since the OPS can determine where the occupant is, it can be used to control the inflation rate.

In each of the examples above, the position and velocity of the occupant is used to prevent or control the inflation of the airbag. In some cases the presence of an occupant, or of a rear facing child seat, can be used to control the deployment of the airbag. A child in a rear facing child seat can be injured if the airbag deploys and if the seat is unoccupied, there is no need to deploy the airbag. In these cases rather than the determination of the position of the occupant, the pattern of a rear facing child seat or of an occupant must be determined and differentiated from that of a forward facing child seat, a box or a bag of groceries. Thus two different technologies are required for the OPS, position and velocity determination and pattern recognition.

Timing Requirements for Position and Velocity Determination

As discussed above, if an occupant is positioned against the airbag when it deploys, he or she can be seriously injured or killed by the deployment itself. This can happen with small people who naturally sit close to the steering wheel even if they are wearing their seatbelts, or with larger people who have fallen asleep. It can also happen due to pre-crash braking or for a variety of other reasons. Also, all current crash sensor systems can trigger late in a crash after the occupant has already been forced against the airbag by the accident deceleration. This is particularly the case with new electronic single point sensors.

Several technologies exist which will permit a measurement to be made of the position and velocity of the occupant. These include laser optics, passive infrared, ultrasonics, optical focusing and radar. Of these, ultrasonics is the least expensive technology however it is slower than the radar and laser optics systems since it is limited by the velocity of sound. This limitation is not significant for determining the initial position of the occupant at the time of the start of the crash since the vehicle will not have changed its velocity and the occupant will therefore not have a significant velocity relative to the instrument panel.

The following analysis shows that an accurate determination can be made of the occupants relative velocity and thus whether or not to deploy the airbag even with the inherent delay caused by the time it takes for the signal to travel to the occupant and return.

The speed of sound in air is approximately 30 cm per millisecond (ms), so if the sonic transmitter and receiver are about 60 cm from the occupant, then the time from the transmission of a pulse until its reception is about four ms. This has two effects: at any time the latest distance measurement shows what the distance was at least two ms earlier and as much as six ms earlier, and the rate of distance measurements is limited to one per four ms. (The 60 cm distance should be an upper bound. Some occupants will be always closer, and others will move closer during the crash. The sonic pulses will be sent more rapidly as the occupant approaches the transceiver.)

These times can be significant only during a crash. For all other applications of the occupant position sensor (OPS), these sampling rates are more than adequate.

During a crash, the OPS would be used to disable the airbag deployment when the occupant is close enough to the airbag module that his/her interaction with the deploying airbag would cause serious injury. The driver-side airbag takes about 30 ms to deploy, and when it is fully deployed it extends about 28 cm from the steering wheel. A design criterion for the airbag system is that deployment should begin at least 30 ms before the average male driver is within 28 cm of the steering wheel. In many crashes though this criterion cannot be met for the actual driver, and not all interactions with the deploying airbag lead to serious injuries. Thus a specification for the OPS might be that the occupant not be allowed to hit the airbag when he/she is less than perhaps 10 cm from the steering wheel. This would balance the injury from the airbag against the injury from striking the steering wheel if the airbag were not there. Naturally, tests must be run to determine this number for a particular airbag system.

The time after the deployment signal is given until the airbag is 10 cm from the steering wheel will depend on the system, but may be about 10 to 12 ms. Therefore, the OPS must be able to predict where the driver will be 10 to 12 ms after the crash sensors have decided that the crash merits an airbag. With a sonic system this might require a 16 ms extrapolation from the latest data point. For a typical 48 kph barrier crash the deployment decision can be made at about 20 ms, and 10 to 12 ms after this an unrestrained driver has moved about 3 cm relative to the car. If the driver is then in the critical zone, then he/she would be only 13 cm from the steering wheel initially. The OPS has plenty of time to determine the initial position, and can disable the airbag system when the driver is initially less than 13 cm from the steering wheel.

For a lower speed barrier impact, or for a softer (longer duration) crash, the driver may have moved farther and have a higher relative velocity when the deployment decision is made. But this takes a longer time which means that more position samples are available. For example, in a 24 kph barrier crash the occupant has moved 5 cm at 50 ms. By 16 ms earlier 8 or 9 position data samples have been taken. The relative motion of an occupant, restrained or unrestrained, is quite smooth until the occupant strikes a hard object, and a sufficiently accurate extrapolation for 16 ms is easily possible with 8 sample points. If the occupant initially is farther from the steering wheel, then even more sample points are available before he/she approaches the critical zone.

Thus the turnaround time for the sonic pulse is not a serious problem for the foreseen applications of the occupant position sensor.

It should also be noted that using only the occupant position sensor is a worst case situation. Most airbag systems have an accelerometer which permits a determination of the relative velocity of the vehicle toward an unrestrained occupant. This additional information can be used to determine whether the occupant is being restrained by a seatbelt and to get even a more accurate extrapolation of his or her position forward in time.

Child Seat Detection and Pattern Recognition

The OPS market is now being driven more by the need to prevent deployment of the airbag when a rear facing child seat is present then when an occupant is out-of-position. This becomes a problem of pattern recognition where the pattern of all "approved" child seats must be distinguished from an occupant. In the full implementation, the presence of an empty seat is also detected and the airbag deployment suppressed. There are many technologies which could potentially solve this problem and rather than discuss them in detail, a list of proposed tests for any candidate technology will be presented.

Here significant technical problems result from the various permitted actions of the passenger, which are unlikely for the driver, such as reading a newspaper or map while the vehicle is in motion.

In a similar manner that airbag crash sensors must

perform properly when subjected to a "library" of standard crashes (which may or may not represent the spectrum of real world crashes), a library of tests can be formed for the Child Seat and Occupant Presence Detectors (CSOPDs). Fortunately, the cost of conducting a test from such a library is inexpensive especially compared to the cost of a crash test which may approach $100,000. This permits the library to be quite large and also permits the use of technologies which may not be as easily understood as more conventional computer algorithms.

Before discussing particular tests in the CSOPD test library, a definition of what constitutes a pass or failure of a test is necessary. In most cases it is only necessary to detect a rear facing child seat or an empty seat once during a trip by a vehicle. It is unlikely, although not impossible, that once a rear facing child seat has been placed on the vehicle seat and the vehicle begins moving, that it will be moved from the front to the back of the vehicle. It is also unlikely that the vehicle will get into an accident requiring deployment of the airbag within the first minute or so of the trip. Therefore there is plenty of time for the CSOPD to detect that a rear facing child seat is present and once it has made that decision it need not change unless the evidence is strong that the child seat is no longer present. For the CSOPD to pass a particular test, therefore, it should be permitted at least a minute to reach a decision and it should not change its decision unless the test condition has changed requiring such a decision change.

As with airbag crash sensors, the test library applies to each model vehicle on which the CSOPD is to be used unless it can be shown that the technology is not influenced by the vehicle.

Rear Facing Child Seat Presence Tests

Each test should be performed for each "approved" child and infant seat. The technology should recognize the presence of a rear facing child seat regardless of: the position of the child seat on the vehicle seat; the position of the vehicle seat; whether the child seat is belted or not; the angular orientation (yaw) of the child seat as long as it is facing substantially rear; the front to back angular orientation (pitch) of the child seat; and, the presence of blankets, dolls, toys or other objects on the child seat. The number of such tests will depend on the nature of the technology used for the CSOPD.

Forward Facing Child Seat Presence Tests

Tests similar to those discussed above should be repeated with the child seat facing forward to demonstrate that the airbag is not disabled.

Occupant Presence Tests

A variety of occupants should be used which represent the extremes as well as the norm of the human population. Once again the particular choice of tests will depend on the particular CSOPD technology used. For this series of tests, the object is to see if the CSOPD can be fooled into thinking that the occupant is a rear facing child seat or that the seat is empty. Occupants should read newspapers, lie down on the seat, sit very near to the driver, wear heavy bulky clothing, hats or anything else which might fool the system.

Empty Seat Tests

A series of tests using packages, bags of groceries, etc., should be conducted to demonstrate that such objects are not misinterpreted as a child seat or an occupant. If the CSOPD fails a test in this series, the consequences are not serious since it will fail to suppress the airbag in the event of an accident. If this were a common occurrence, however, the customers or their insurance companies, might become annoyed.

Other Tests

Finally, a series of tests using animals, for example, and any other situations which might defeat the CSOPD technology should be identified based on an understanding of the particular technology. If ultrasonics are used, for example, the effects of wind noise or any other sources of noise, either ultrasonic or audible, should be investigated.

Automobile manufacturers are now concerned that they must tell customers that the child seats must be on the rear seat of the vehicle. They are even more concerned about the situation in trucks, one of the fastest growing markets, where there is no rear seat. The OPS market is now being driven by the desire to prevent the deployment of the passenger side airbag if a rear facing child seat is present on the front passenger seat.

Technology Comparisons

The following is a brief review of available technologies.

Passive infrared

In this system, the CSOPD responds to the temperature of the occupant which can either be a child in a rear facing child seat or an occupant. The sensing of the child could pose a problem if the child is covered with blankets. It also might not be possible to differentiate between a rear facing and forward facing child seat. In all cases, the technology will fail to detect the occupant if the ambient temperature reaches body temperature as it does in hot climates.

Laser Optical

In this system a laser beam is momentarily used to illuminate an occupant or child seat. Many variations of the technology are possible such as using a charge coupled device (a type of TV camera), a scanning system, or a cone of light which covers a large portion of the object coupled with a pattern recognition system. This and the radar system can provide the most information about the object and at a rapid data rate. Their main drawback is their cost which is considerably above that of ultrasonic systems. As the cost of lasers comes down in the future, this system will become more competitive. Depending on the implementation of the system, there may be some concern for the safety of the occupant if the laser light can enter the occupants eyes.

Radar

This system has similar properties to the laser system discussed above. Once again there is some concern about the health effects of radar on children and other occupants.

Ultrasonic

This is the least expensive system and potentially provides less information than the laser or radar systems due to the delays experienced resulting from the speed of sound and due to the wave length which is considerably longer than the laser or radar systems and which limits the detail which can be seen by the system. In spite of these limitations, as shown above, ultrasonics can provide sufficient timely information to permit the position and velocity of the occupant to be accurately known. The use of ultrasonics to determine the presence of a rear facing child seat has also been demonstrated.

Focusing

Focusing systems, such as used in some camera systems, could be used to determine the initial position of an occupant but would be too slow to monitor his position during a crash. Also by itself it cannot determine the presence of a rear facing child seat or of an occupant.

Conclusions

With the expected installation of side impact airbags, which will be initially stored in the doors of the vehicle, the potential for deployment induced injuries will increase significantly. The head of a small child, for example, may be adjacent to the deployment door of such an airbag especially if he is sleeping against the door. Therefore the CSOPD will eventually be needed for side impact airbags. Some manufacturers are now experimenting with rear seat airbags. As the number of airbags in a vehicle increases, the need for occupant presence detection, and for rear facing child seat detection, also increases. It would not be tolerable to deploy multiple airbags in a frontal or side impact, for example, if the vehicle has only one occupant.

Once a CSOPD is present in a vehicle, other possibilities suggest themselves such as the monitoring of the driver's behavior which can be used to warn a driver if he or she is falling asleep, or to stop the vehicle if the driver loses the capacity to control it. Additionally, a mapping of the vehicle occupants can be used to adjust the heating, air conditioning or sound in the vehicle. Finally, in the case of an accident, the information as to the number of occupants can be transmitted automatically using the vehicle's cellular phone to call for help and order the requisite number of ambulances. Perhaps a more advanced system will someday be used to recognize the driver, automatically adjust the seat, mirrors etc. and even control who is permitted to operate the vehicle!

References

1. Mertz, Driscoll, Lenox, Nyquist and Weber titled "Response of Animals Exposed to Deployment of Various Passenger Inflatable Restraint System Concepts for a Variety of Collision Severities and Animal Positions" SAE 826074, 1982

2. Breed, D.S., Castelli, V. "Trends in Sensing Frontal Impacts", Society of Automotive Engineers No. 890750, 1989.

3. Breed, D.S., Sanders, W.T. and Castelli, V. "A Critique of Single Point Crash Sensing", Society of Automotive Engineers No. 920124, 1992.

Figures

Name	Size	Kind	Last Modified	
ATI 77 FIG. 1	7K	MacDraft 1.3 doc...	Fri, Apr 29, 1994	3:48 PM
ATI 77 FIG. 2	13K	MacDraft 1.3 doc...	Fri, Apr 29, 1994	3:46 PM
ATI 77 FIG. 3	13K	MacDraft 1.3 doc...	Fri, Apr 29, 1994	3:52 PM
ATI 77 FIG. 4	13K	MacDraft 1.3 doc...	Fri, Apr 29, 1994	3:57 PM
ATI 77 FIG. 5	13K	MacDraft 1.3 doc...	Fri, Apr 29, 1994	4:00 PM
ATI 77 FIG. 6	13K	MacDraft 1.3 doc...	Fri, Apr 29, 1994	4:04 PM
ATI 77 FIG. 7A	7K	MacDraft 1.3 doc...	Tue, Apr 5, 1994	5:09 PM
ATI 77 FIG. 7B	7K	MacDraft 1.3 doc...	Tue, Apr 5, 1994	5:10 PM
ATI 77 FIG. 8	7K	MacDraft 1.3 doc...	Mon, May 2, 1994	10:39 AM
ATI 77 FIG. 9	13K	MacDraft 1.3 doc...	Fri, Apr 29, 1994	4:16 PM
ATI 77 FIG. 10	13K	MacDraft 1.3 doc...	Tue, May 3, 1994	4:29 PM
ATI 77 FIG. 10.1	7K	MacDraft 1.3 doc...	Mon, May 2, 1994	2:33 PM
ATI 77 FIG. 11	13K	MacDraft 1.3 doc...	Mon, May 2, 1994	11:09 AM
ATI 77 FIG. 12	13K	MacDraft 1.3 doc...	Mon, May 2, 1994	11:18 AM
ATI 77 FIG. 13	13K	MacDraft 1.3 doc...	Mon, May 2, 1994	11:21 AM
ATI 77 FIG. 14	7K	MacDraft 1.3 doc...	Mon, May 2, 1994	11:37 AM
ATI 77 FIG. 15	13K	MacDraft 1.3 doc...	Fri, Apr 29, 1994	4:54 PM
ATI 77 FIG. 16	13K	MacDraft 1.3 doc...	Mon, May 2, 1994	11:59 AM
ATI 77 FIG. 17	13K	MacDraft 1.3 doc...	Mon, Apr 4, 1994	4:07 PM
ATI 77 FIG. 18	13K	MacDraft 1.3 doc...	Fri, Apr 22, 1994	4:15 PM
ATI 77 FIG. 18.1	13K	MacDraft 1.3 doc...	Tue, May 3, 1994	4:28 PM
ATI 77 FIG. 19	13K	MacDraft 1.3 doc...	Tue, May 3, 1994	4:38 PM

STATEMENT

47572

Date APRIL 29 1994

TO Dr David Breed
AUTOMOTIVE TECHNOLOGIES INT'L, INC.
P.O. Box 1028
Denville, N.J. 07834

TERMS NET 10

IN ACCOUNT WITH
SAMUEL SHIPKOVITZ, Ph.D.
5829 Nicholson Street
Pittsburgh, PA 15217

			Paid 8/16/94
Apr 23	ATI 68 Fuel Tank 1.75 hr eng		
APR 24	ATI 77 VIMS 1.0 phone DBreed est	8 00	Check # 2337
APR 25	ATI 77 ATI 68 } clm term 1.0 1.0		
APR 26	ATI 77 2.75		
APR 27	VIMS 1.75		
	Faxed 6 pp 305/534 2405 day ATI 39 Restr	9 00	
APR 28	ATI 38.1-2d Request for Restriction 1.0		
APR 29	update search Computer run .4 hr postage	52	
	ATI 38.1-24 Response 2.5 hr		
	recd 20 pp FAX	7 00	
	sent 4 pp FAX	4 00	
	Kinko's copies	3 15	
	redraft Request/new claim 1.25 hr		
	TOTALS: 14.4 hrs eng		
	EXPenses:	31 67	

Stock Form 25812

STATEMENT

47570.

Date APRIL 18 1994

TO Dr David Breed, President
AUTOMOTIVE TECHNOLOGIES INT'L, INC.
P.O. Box 1028
Denville, N.J. 07834

TERMS NET 10

IN ACCOUNT WITH
SAMUEL SHIPKOVITZ, Ph.D.
5829 Nicholson Street
Pittsburgh, PA. 15217

MAR 11	make 2 copies of ATI 39 [illegible] to DB	20 00 / 2 90	
MARCH 16	review of ATI 33.1/33 3 hrs		
MARCH 17	disc re: foreign filings to be made by others NOT me KFM, M Foyich 1 hr		
MAR 25 / MARCH 28	disc re: foreign filings to be made by others not ME .5 hr / disc re: foreign filings to be made by others not me .5 hr		
	phone calls + FAXing Foyich letter 6 pp	9 50	
MAR 24-25	disc w/Mike Foyich, Esq re: foreign filings 3 misfeeds .5 hr Genera Japan		
Mar 28	disc w/Mike Foyich, Esq re: PCT Request .5 hr		
Mar 29	disc w/DB re: KFM .1 hr		
Mar 31	FAX ATI 39 Pet re: order of names granted FAX ATI 38.1 Restriction Request 1 Mo. letter		.1 hr
APR 10-12	ATI 77 review ATI 68 review/disc w DB	2 00	1.0 hr
APR 11-12	ATI 33.1 prog A 5.0 hrs est phone	3 50	
APR 13	ATI 33.1 prog A 3.5 hr est phone	3 00	
APR 14	ATI 33.1 prog A 2.5 hr est phone	3 00	
APR 15	ATI 33.1 prog A / conf DB Interview call to DB est	4 00	6.0 hr
Apr 16	ATI 33.1 Amendment 2.7 hrs		
Apr 17	phone calls / FAXing est	8 80	
Apr 17	total call to DDF Cal est	4 50	.1 hr
	ATI 77 VIDBMS review DBreed / ATI 68 Fuel Tank Fuel Mass		2.5 hrs

Stock Form 25812